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(71) Applicant (*for all designated States except US*): **TELIA AB (publ)** [SE/SE]; Mårbackagatan 11, S-123 86 Farsta (SE).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): **LJUNG, Rickard** [SE/SE]; Hantverkaregatan 20, S-211 55 Malmö (SE). **KARLSSON, Peter** [SE/SE]; Blåbärsstigen 7, S-201 00 Lund (SE).

(74) Agent: **SVENSSON, Peder**; TeliaSonera Sverige AB, Patent, Vitsandsgatan 9, S-123 86 Farsta (SE).

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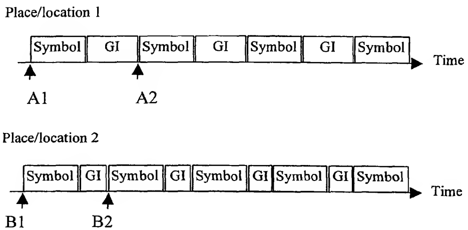
(54) Title: POSITION ADJUSTED GUARD TIME INTERVAL FOR OFDM-COMMUNICATIONS SYSTEM



(57) Abstract: A device and a method within a communications system where at least some part of the transmission is executed by means of radio waves, and where symbols are transmitted by means of Orthogonal Frequency Divisional Multiplexing, so called OFDM-technology, between a transmitting unit and a receiving unit, at which the symbol transmission is executed over a transmission channel in blocks of binary digits with a guard interval GI between said blocks, where transmitting unit is equipped with means to control the length of the guard interval (GI) with regard to the physical conditions for/of the transmission channel, so that the guard interval can be reduced without the disturbance susceptibility being increased, but instead increasing the capacity/throughput of the transmission channel by the time that is set free/made available being used to transmit information. One embodiment of the invention includes a guard interval adjustment unit connected to other OFDM-equipment in transmitting and/or receiving unit.

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POSITION ADJUSTED GUARD TIME INTERVAL FOR OFDM-COMMUNICATIONS SYSTEM

Technical field

The present invention relates to a transmission method and a transmission device, and a reception method and a reception device, and a system using them. More particularly is related to such ones within communications systems which are using OFDM (Orthogonal Frequency Divisional Multiplexing).

Prior art

An information transmission system generally transmits symbols, where each symbol for instance can be a sequence of ones and zeros in succession over a transmission channel, and there occupies a frequency band which of necessity must be wider/larger than the inverse of the time length of a symbol.

When the transmission speed is increased it finally will be impossible to guarantee that the transmission channel retains identical amplitude and phase characteristics over the whole frequency range which constitutes the pass band. These in this way developed distortions in the channel give rise to interference between symbols, which interference can be fought against by means of an equalizing device, a so called equalizer. Such systems, however, are rather complex.

One technology to handle/manage this problem includes that the signal which shall be transmitted is spread/distributed over a large number of carriers in a parallel way, individually modulated with/by low speed. Because the speed is low, the pass band width which is needed is smaller, and therefore it is more probable that amplitude and phase characteristics will be identical for all frequencies which

constitute this band. This technology is known to the expert as "Orthogonal Frequency Divisional Multiplexing" or OFDM. Frequency spectra of the signals which modulate the carriers overlap in such a way that they fulfill the conditions for orthogonality, which makes elimination of interference between modulated sub-carriers possible and also makes it possible to achieve much larger spectral benefit.

The space between two adjacent sub-carriers corresponds to the inverse of the time length of a symbol.

The OFDM-modulation is usually incorporated with a Fourier-transform, so that it can be implemented by means of FTT (Fast Fourier Transform). The main steps to implement transmission of a message by means of OFDM-modulation is specified below.

First of all the binary data which constitute the message which shall be transmitted in data blocks are grouped. Each one of these blocks is transmitted independent of each other and constitutes, after base band modulation, an OFDM-signal. In each data block also the binary digits are grouped in subset. Each subset after that is subject to a "bijective mapping" over a discrete amount of points in the Fresnel-space, where each point represents a possible phase and amplitude. If, for instance, a message consisting of the following series of bits (00001110010001111000...) is considered, it will be possible to from that extract a block of 16 bits 0000111001000111, with which are associated, by mapping, the following amount of points in the complex plane:
1+j, 1+j, -1-j, 1-j, -1+j, 1+j, -1+j, -1-j.
This consequently gives an amount consisting of eight complex elements, which define a vector V.

An inverse discrete Fourier Transform with a matrix A then is allowed to be active/influence on the vectors V which have been obtained from the original message, which gives rise to an OFDM-signal consisting of a series of complex amplitudes.

Each transmitted/transferred symbol then is received, after having passed the transmission channel, by a demodulator, from which there is extracted a vector V´ which holds complex elements, by multiplying the amplitudes which describe the symbol by/with a direct discrete Fourier-transform matrix A´ so that A*A´= I, where I indicates the unit matrix.

The use of a decision criterion based on ”Maximum likelihood” on the real part and on the imaginary part of each vector V´ makes regain of the original symbol sequence possible and further reconstruction of the to that associated binary elements.

The different symbols in each block are linked up due to the linear combination which is obtained by multiplying the elements in the transmitted vector V by the inverse discrete Fourier-transform matrix A. This linear combination guarantees a certain degree of hardiness and protects the symbols against interference between complex symbols within one and the same OFDM-symbol.

On the other hand, this protection/guard effect does not extend from one OFDM-symbol to another, that is, not from one block to another.

In order to prevent interference between blocks, it is known that a technology can be used which includes to arrange a time period of silence or non-transmission, also

called guard (time) interval, between to successive symbols.

In prior art, however, the guard interval preceding current symbol is decided pragmatically, usually after an evaluation by an expert, of the time period which is necessary to attenuate the echo of the transmission of preceding OFDM-symbol.

Some variants including adjustment of the guard interval are also described below.

US-6115354-A shows a method which adapts the "guard intervals for the OFDM symbols" to those differences in delay which exist in the network. The first guard interval for a frame, however, is adjusted to "worst case" (see column 2, line 9 - column 3, line 9). According to this document, the flexibility of the guard interval results in that the OFDM-system can be optimized both from implementation and network planning perspective (see column 3, lines 36-40).

US-6175550-B1 shows an OFDM-system in which a "guard time interval" is adjusted dynamically depending on the communication conditions in the environment (see column 3, lines 3-65), column 6, lines 24-32, and independent patent claims).

EP-1065855-A1 shows adjustment of "cyclic extensions" in an OFDM-system. The length of the cyclic extension is adjusted to the delays which are existing at/in the channel. (See abstract)

WO97/30531-A1 says that a "guard space" can be varied so that a minimal guard space is used (see patent claims).

EP-1061687-A1 shows automatic adjustment of "guard interval" depending on the quality of received signal.

EP-1014639-A2 shows an OFDM-transmitter/receiver for which an optimal selection of guard interval is decided.

Summary of the invention

At construction of a communications system it is in most cases adjusted to a "worst case". This results in that in all other cases than the worst possible, capacity will be wasted. This invention solves a large part of above mentioned waste of/for an OFDM-system, where the capacity goes down proportionally with the guard interval against the time dealy of the channel, "Guard Interval GI". The problem is solved by adjustment of the basic OFDM-structure for each transmitter/base station so that not utilized time between symbols will be negligible and the larger part of the transmitted power can be utilized by the terminals.

The invention relates to a communications system where at least some part of the transmission is executed by means of radio waves, and where symbols are transmitted by means of Orthogonal Frequency Divisional Multiplexing, so called OFDM-technology, between a transmitting unit and a receiving unit, at which the symbol transmission is executed over a transmission channel in blocks of binary digits with a guard interval GI between said blocks, where transmitting unit is equipped with means to control the length of the guard interval with regard to the physical conditions for/of the transmission channel.

Brief description of the drawings

The invention will be described in more details in the following with reference to the enclosed drawings, of which:

Figure 1a shows symbol start points of time and guard intervals in a symbol transmission sequence;

Figure 1b shows a block diagram over a system solution comprising guard interval adjustment according to one embodiment of the present invention;

Figure 2 shows geographical distribution of cells and to that associated guard interval;

Figure 3 shows a block diagram over a two-way communications system where the guard interval adjustment is based on current channel estimate from a WCDMA-receiver; and

Figure 4 shows a block diagram over a system solution according to another embodiment of the present invention.

Description of preferred embodiments

An OFDM-system is defined by certain basic parameters such as the number of FTT-points, the size of the so called guard interval GI, sampling speed, bandwidth etc. Several of these parameters are selected for the worst case, that is, for the most difficult possible communications condition in which the system shall be functioning satisfactorily. The guard interval means that power and time between OFDM-symbols are not utilized. The guard interval is decided for such a system so that all receivers shall have possibility to receive and detect symbols without intersymbol interference ISI occurring. The worst conceivable propagation delay in the radio channel therefore will be dimensioning for the length of the guard interval.

At normal use of a communications system, however, there sometimes will be considerably better conditions, which means that the parameters which have been selected at the design/construction of the system are too resource exacting because they are not adjusted to at present existing conditions. The inventors have realized that, by adequate

measures, it will be possible to, by reducing the guard interval from 1/4 to 1/8, 1/16, and 1/32, increase the system capacity correspondingly. In a system for distribution "one-to-many" (point-to-multipoint), however, it is not practical to change the guard interval GI for each separate receiver because all OFDM-symbols are transmitted to all receivers within the coverage area.

One of the ideas behind the invention includes to by, in access points AP or base stations BS in a communications system, designing/constructing the OFDM-transmitter in such a way that the guard interval GI can be adjusted as an installation parameter, the guard interval of the OFDM-signal can be adjusted to existing channel conditions from the transmitter within each separate coverage area, also called cell. When a new receiver is connected in this cell, it will be possible to, for instance, via an adjustment algorithm, for instance such as is described by Kim et al, "Frame Selection Algorithm with Adaptive FFT input for OFDM Systems", at ICC, the International Chamber of Commerce 2002, automatically change to the guard interval selection of this cell.

The algorithm is functioning in such a way that it identifies where the OFDM-symbol really starts, that is, estimates how wide/large guard interval that is used. In Figure 1a consequently is visualized that the algorithm identifies the occasions which have been marked with arrows A1, A2, B1, B2 at the time axis, that is, where OFDM-symbols start. The figure includes examples of two different places, Place 1 and Place 2, where on the one hand a long and on the other a short guard interval is used. By the algorithm, which is built-in in receiving unit, here called the terminal, identifying where the OFDM-symbol starts, the guard interval can be selected by the operator based on what each specific cell looks like,

without any setting needed to be changed in the terminal when the terminal is moved between different cells. In other words, the algorithm executes frame synchronization by in receiving unit calculating an estimate of the guard interval GI by using the in the time domain received signals, and by calculating an estimate of the difference between received and expected frame start time, the so called "coarse framing offset", $\hat{\delta}_{\text{int}}$ expressed as

$$\hat{\delta}_{\text{int}} = \arg\min_{n} \left\{ \frac{1}{G} \sum_{l=0}^{G-1} \left| \left| y_{i,l+n} \right|^2 - \left| y_{i,l+n+N} \right|^2 \right| \right\}$$

where n=0,1,2.., 2G + 2N -1 and G indicating the sample length at the guard interval.

The guard interval GI then can, as indicated above, in a flexible way be adjusted to/for each cell in the communications system, and the capacity/throughput can be improved in the system. This is illustrated in Figure 1. A communications system consists of a network core 101 which via a connection 151 is in connection with two adjacent/ nearby located transmission units 111, 112. The physical distance between the transmission units 111, 112 is α. Each transmission unit has, via ether communications 151, 152, contact with at least one terminal 121, 122. A network monitor unit 131 monitors the system and handles system parameters. The network monitor unit 131, together with the OFDM-modules 115, 116, attends to that the guard interval GI is adjusted to the distance α between the transmission units in such a way that the guard interval is adjusted to the cell radius. Suitable guard interval parameter GI is applied to/in OFDM-module 115, 116, and further respective terminal 121, 122 is arranged to adjust itself to the guard interval GI of the cell. The guard interval GI should be selected so that it corresponds to the maximum time dispersion a received signal can experience in respective

coverage area. For instance, if there in a cellular system is about 100 m cell radius, the distance for a reflected signal can be up to about 200 m. The flexible guard interval GI consequently is adjusted to handle the delay 200 m, which corresponds to a guard interval GI of about 600 ns. For a cell with a radius of 200 m, about 1200 ns is selected, that is, so that the length of the guard interval in nanoseconds is set to, on the whole, six times the cell radius in meters. The principle for selection of size of the guard interval GI is illustrated in Figure 2.

In one preferred embodiment, the parameter GI can be preset by the operator or the system administrator via the ordinary interfaces for setting/adjustment of a radio channel, modulation etc in each access point AP and each base station BS. Setting of the parameter guard interval GI by/from a centrally located administrator, operator or separate user results in that one continuously achieves optimal performance without need to change hardware at the place of respective access point AP or base station BS. The invention by that includes the possibility to improve capacity performance for an OFDM-system both initially and when the system is extended by more access points AP or base stations BS.

In a cellular two-way communications system based on OFDM and according to one embodiment of the invention, consequently a flexible adjustment of the guard interval GI is achieved. Said guard interval GI is adjusted to the existing transmission conditions in each cell. In another embodiment, each terminal 121, 122 is equipped with an automatic adjustment unit 310 which automatically adjusts the guard interval GI in the cell of current interest so that mobile units can move in the cellular system and adjust their reception to the flexible parameter selections of the different cells.

In tests an OFDM-system according to one embodiment of the invention and based on IEEE 802.11a has been tested and verified in indoor environment. In these comparatively small cells with maximum distances of about 50 m between transmitter and receiver, no symbol errors due to time dispersion of the channel have been measured. The standardized guard interval for OFDM in IEEE 802.11a is 800 ns, which by use of one embodiment of the present invention should be possible to reduce to 400 ns in most indoor environments.

In Figure 3 a structure for/of the OFDM-module 115, 116 according to Fig. 1 is described. An automatic guard interval adjustment unit 310 is in connection with other electronics 315 for execution of OFDM. The guard interval adjustment unit 310 calculates the under the circumstances best guard interval and transmits this to other electronics 315 for execution of OFDM.

In one preferred embodiment, the guard interval is adjusted according to longest delay in the impulse response. Because the delay, however, maximally can be about the time it takes for the signal to travel twice the cell radius, this value can be supposed to be a suitable guard interval, that is (distance between base stations)/($3*18^8$). As a rule of thumb, it can be assumed that radio waves travel 300 m in 1 microsecond, and if there is this distance between BS, and consequently 150 m max. between BS and terminal, the guard interval should be 1 microsecond in this typical example in city environment. For BS in suburb with 1 km between BS, one should have 3 microseconds guard interval.

It is not necessary to, in all situations, calculate the guard interval in an embodiment of the invention. The guard interval can be calculated before the base station is

installed, for instance at the cell planning occasion, and after that only when changes in the network planning are made.

The guard interval consequently need not necessarily be calculated anywhere in the system. If one concentrates with more BS one can, via handling/managing system SNMP, reduce the guard interval with corresponding new shorter BS-distance so that more OFDM-symbols are transmitted within each time frame or block of symbols.

In yet another preferred embodiment there is in a receiver which receives the OFDM-signal a receiver adjustment module arranged which adjusts said receiver according to the current guard interval in the cell. Said adjustment is made by use of an adjustment algorithm described in "Frame Selection Algorithm with Adaptive FFT Input for OFDM Systems, ICC 2002", which has been described above.

In yet another embodiment of the present invention, an adjustable guard interval GI in a two-way communications system according to Figure 4 is provided.

In a two-way communications system, where communication is executed both in an uplink UL and in a downlink NL, an adjustment of the parameters of the OFDM-signal can be made to existing communication conditions, which increases the capacity/throughput of the system. In order to receive a transmitted signal, an estimation of the qualities of the transmission channel is made. For instance, the delays and the changes of amplitude which occur between transmitter and receiver are measured. This so called channel information from the receivers of the system by that can be utilized for the generation of the signals in the OFDM-transmitter, where one, by knowing the impulse response of the channel, can adjust the guard interval GI of the OFDM-

signal to existing channel conditions from the transmitter within each separate coverage area, and also for each terminal within the coverage area. The impulse response is produced in receiving unit by estimating the channel from a transmitted symbol in a so called "preamble". The principle is illustrated in Figure 4, where the guard interval GI is adjusted based on current channel estimate from a WCDMA-receiver 430. The channel estimate is transmitted/ transferred to the OFDM-unit 440 where the guard interval GI is adjusted on basis of current channel estimate.

A radio network control unit RNC is in (wire) connection with a number of nodes, one of which is node B.

The guard interval should be equal in up and down link; then in systems using TDD (Time Division Duplex), the up and downlink of the channel is identical, and the same guard interval should be used.

The system in Figure 4 also includes a so called dual mode terminal 450, which is arranged to receive both OFDM- and WCDMA-signals. This terminal 450 includes a channel estimation unit 460 for production of channel estimates and an estimation unit 470 for estimation of impulse responses from WCDMA-training sequences. Said estimate and estimation then is used to adjust the guard interval OFDM in downlink.

In yet another preferred embodiment, the guard interval is designed as a copy of the last symbols in each block. These symbols are copied and are also inserted first in each block before transmission.

PATENT CLAIMS

1. A transmitting unit within a communications system where at least some part of the transmission is executed by means of radio waves and in cells, and where symbols are transmitted by means of Orthogonal Frequency Divisional Multiplexing, so called OFDM-technology, between a transmitting unit and a receiving unit, at which the symbol transmission is executed over a transmission channel in blocks of binary digits and with a guard interval GI between said blocks, c h a r a c t e r i z e d in that said transmitting unit is equipped with means to control the length of the guard interval (GI) with regard to the size of the cell in which transmitting unit is located.

2. The transmitting unit as claimed in patent claim 1, c h a r a c t e r i z e d in that said means to control the length of the guard interval (GI) includes a guard interval adjustment unit (310) including an adjustable guard interval parameter.

3. The transmitting unit as claimed in patent claim 2, c h a r a c t e r i z e d in that said guard interval parameter can be changed via handling/managing system SNMP.

4. The transmitting unit as claimed in patent claim 2, c h a r a c t e r i z e d in that said guard interval adjustment unit (310) calculates a guard interval with regard to the size of the current cell.

5. The transmitting unit as claimed in patent claim 2 where the guard interval has been adjusted to the size of the cell in such a way that the length of the guard

interval in nanoseconds is set to, in the main, six times the cell radius in meters, that is, for a cell with the radius 100 meters, the length of the guard interval is set to/at 600 nanoseconds.

6. The transmitting unit as claimed in patent claim 3, c h a r a c t e r i z e d in that said guard interval adjustment unit (310) also takes into consideration the impulse response of the transmission channel.

7. A receiving unit within a communications system as claimed in patent claim 1, c h a r a c t e r i z e d in that the receiving unit is equipped with an adjustment module which adjusts the receiving unit according to the current guard interval in the cell.

8. The receiving unit as claimed in patent claim 7, c h a r a c t e r i z e d in that said adjustment is made through/by an operator.

9. The receiving unit as claimed in patent claim 7, c h a r a c t e r i z e d in that, at said adjustment, an algorithm which includes the following step is used:
- estimation of received guard interval.

10. The receiving unit as claimed in patent claim 9, c h a r a c t e r i z e d in that said estimation is made by calculating an estimate of the difference between received and expected block start point of time, the so called "coarse framing offset" $\hat{\delta}_{\text{int}}$ according to the formula:

$$\hat{\delta}_{\text{int}} = \arg\min_{n} \left\{ \frac{1}{G} \sum_{l=0}^{G-1} \left| \left| y_{i,l+n} \right|^2 - \left| y_{i,l+n+N} \right|^2 \right| \right\}$$

where n=0,1,2,.., 2G + 2N -1 and G indicates the sample length at the guard interval. y_1 indicates the received signal of the i:th OFDM-symbol in the time domain.

11. A method within a communications system where at least some part of the transmission is executed by means of radio waves and in cells, and where symbols are transmitted by means of Orthogonal Frequency Divisional Multiplexing, so called OFDM-technology, between a transmitting unit and a receiving unit, at which the transmission of symbols is executed over a transmission channel in blocks of binary digits with a guard interval GI between said blocks, where said method includes the following steps:
    - estimation (510) of channel characteristics, also including production of/finding the size of the cell;
    - estimation (520) of least possible guard interval length which gives rise to an intersymbol interference within acceptable limits;
    - production (530) of/finding guard interval parameter based on said guard interval length;
    - incorporation (540) and use of said guard interval parameter at transmission of symbols from said transmitter.

12. Method as claimed in patent claim 11, where said estimation of channel characteristics also includes production of/finding impulse response of the channel.

13. A method at a communications system as claimed in patent claim 11, including:
    - estimation of received guard interval.

14. A method as claimed in patent claim 13 where said estimation is constituted by one by operator decided guard interval.

15. A method as claimed in patent claim 13 where said estimation is executed by calculating an estimate of the difference between received and expected block start point of time, the so called "coarse framing offset" $\hat{\delta}_{\text{int}}$ according to the formula:

$$\hat{\delta}_{\text{int}} = \arg\min_{n} \left\{ \frac{1}{G} \sum_{l=0}^{G-1} \left| \left| y_{i,l+n} \right|^2 - \left| y_{i,l+n+N} \right|^2 \right| \right\}$$

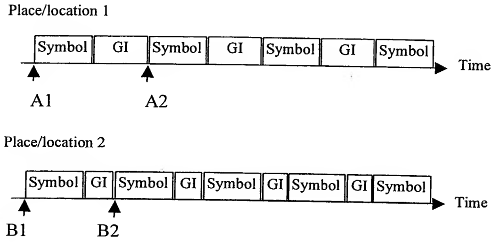
where n=0,1,2.., 2G + 2N -1 and G indicates the length of sample at the guard interval. y_i indicates the received signal for/of the i:th OFDM-symbol in the time domain.

16. A method within a communications system where at least some part of the transmission is executed by means of radio waves and in cells, and where symbols are transmitted by means of Orthogonal Frequency Divisional Multiplexing, so called OFDM-technology, between a transmitting unit and a receiving unit, at which the symbol transmission is executed over a transmission channel in blocks of binary digits with a guard interval GI between said blocks, where said method includes that the length of the guard interval GI is controlled with regard to the size of the cell in which transmitting unit is located.

17. A method as claimed in patent claim 16 where the length of the guard interval GI in nanoseconds is set to/at, in the main, six times the cell radius in meters, that is, for a cell with the radius 100

meters, the length of the guard interval GI is set to/ at 600 nanoseconds.

18. A communications system where at least some part of the transmission is executed by means of radio waves and in cells, and where symbols are transmitted by means of Orthogonal Frequency Divisional Multiplexing, so called OFDM-technology, between a transmitting unit and a receiving unit, at which the symbol transmission is executed over a transmission channel in blocks of binary digits with a guard interval GI between said blocks, c h a r a c t e r i z e d in that said system is equipped with means to control the length of the guard interval (GI) with regard to the size of the cell in which transmitting unit is located.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GI
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Time
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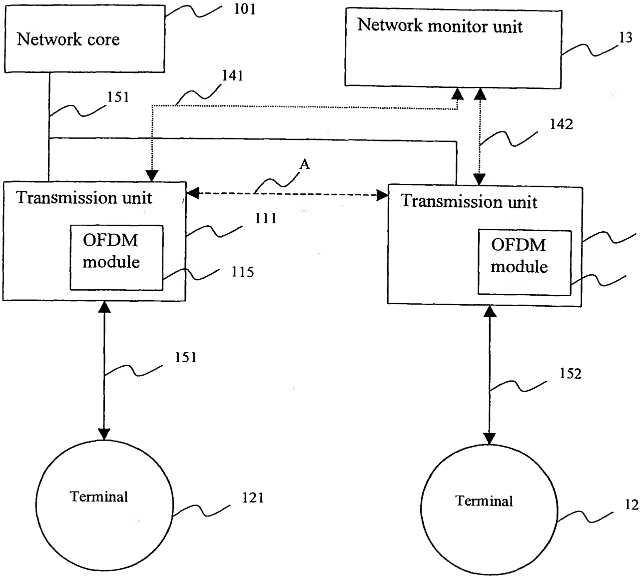
B2

Figure 1a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151
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OFDM module
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152
Terminal
121
Terminal
12

Figure 1b

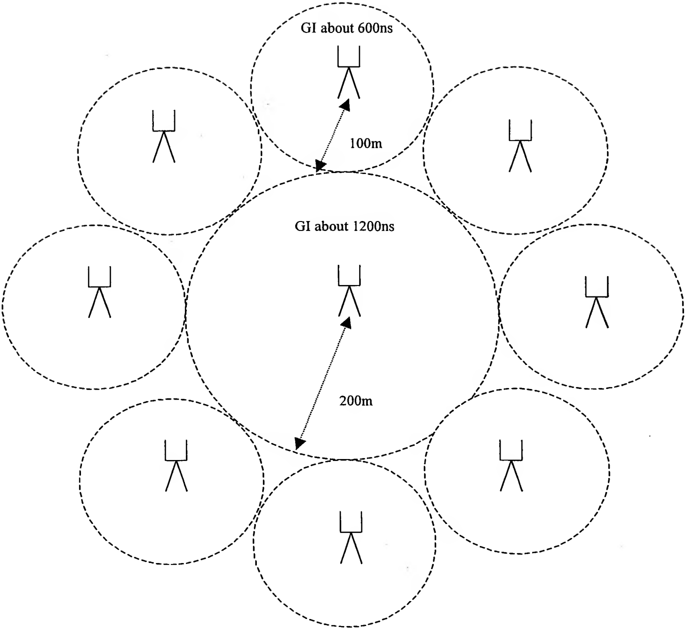

Figure 2

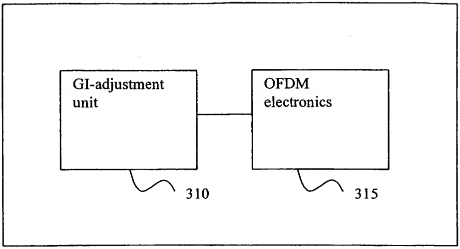

Figure 3

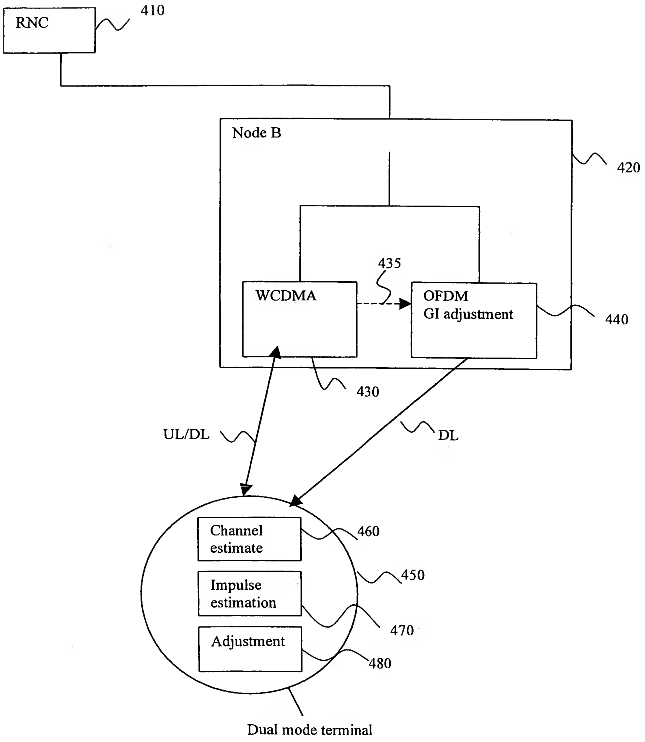
RNC
410
Node B
420
435
WCDMA
OFDM
GI adjustment
440
430
UL/DL
DL
Channel estimate
460
450
Impulse estimation
470
Adjustment
480
Dual mode terminal

Figure 4

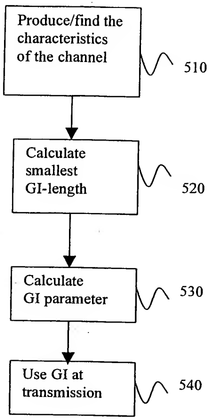
Produce/find the characteristics of the channel
510
Calculate smallest GI-length
520
Calculate GI parameter
530
Use GI at transmission
540

Figure 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 2004/000390

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04L 27/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H04L, H04B, H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1014639 A2 (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD), 28 June 2000 (28.06.2000), see for example claims 1,2,4,5 and paragraphs [0027]-[0028] --	1-18
A	TONELLO, A.M. et al. "Analysis of the uplink of an asynchronous multi-user DMT OFDMA system impaired by time offsets, frequency offsets, and multi-path fading". In: 52nd VEHICULAR TECHNOLOGY CONFERENCE, 2000. IEEE VTS-FALL VTC 2000. Boston, MA, USA, 24-28 September 2000, Vol. 3, pages 1094-1099, INSPEC AN: 6880050, see section 6 "Performance Results of Several System Scenarios" --	1-6,11-18

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
17 June 2004	21 JUN 2004

Name and mailing address of the ISA/	Authorized officer
Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Markus Stålö /OGU Telephone No. +46 8 782 25 00

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN Vol. 1999, No. 02, 26 February 1999 (1999-02-26) & JP 10 308716 A (SONY CORP) 17 November 1998 (1998-11-17) see abstract --	7-10
A	PATENT ABSTRACTS OF JAPAN Vol. 2000, No. 20, 10 July 2001 (2001-07-10) & JP 2001 069110 A (MATSUSHITA ELECTRIC IND CO LTD) 16 March 2001 (2001-03-16) see abstract; description paragraphs [0001] - [0009] --	1-18
A	BAUM, K.L. "A synchronous coherent OFDM air interface concept for high data rate cellular systems" In: 48th IEEE VEHICULAR TECHNOLOGY CONFERENCE, 1998. VTC 98. Ottawa, Ont., Canada, 18-21 May 1998, Vol. 3, pages 2222-2226, INSPEC AN: 6127270, see abstract and section IV. "SC-OFDM downlink configuration" / A. "OFDM signal parameters" -- --------	1-18

EP	1014639	A2	28/06/2000	CN	1260649	A	19/07/2000
				JP	2000244441	A	08/09/2000
				JP	2003023410	A	24/01/2003
				KR	2000052538	A	25/08/2000
				US	6714511	B	30/03/2004